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(54) IMPROVEMENTS RELATING TO POSITION-LOCATING MEANS

(71) We FERRANTI LIMITED, a Company registered under the Laws of Great Britain, of Hollinwood in the County of Lancaster do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

THIS INVENTION relates to position-locating means, and in particular to means for automatically determining the position of each one of a number of movable objects within an area.

Hitherto, the location of movable objects within an area has necessitated either the co-operation of the objects themselves, as in a personnel paging system, or the employment of a person to check at intervals on the location of each object, as is necessary for the location of goods within a warehouse. The first-mentioned system is, of course, not suitable for the location of inanimate objects, whilst the other system mentioned is wasteful of manpower.

It is an object of the present invention to provide means for automatically determining the position of each one of a number of movable objects within an area.

According to the present invention there is provided means for automatically determining the position of each one of a number of objects within an area, which includes a number of inductive loops together dividing the area into separate regions, means for applying to each inductive loop a separate modulated low-frequency carrier wave, a transponder located with each object and capable of responding to the radiated energy in each inductive loop to radiate an uniquely-modulated radio-frequency carrier wave, and receiving means responsive to the radio-frequency carrier wave radiated by each transponder to determine the identity of the object and the region within which it is located.

The term "transponder" is used in this specification to refer to a device which will receive a desired signal, modify the signal in some predetermined manner, and transmit the modified signal in some convenient form.

An embodiment of the invention will now be described with reference to the accompanying drawings, in which:—

Figure 1 is a schematic diagram of means for locating valuable consignments of cargo within a warehouse complex;

Figure 2 is a block diagram of an inductive loop amplifier unit, and

Figure 3 is a block diagram of a transponder.

Referring now to Figure 1, this shows an area 10, representing a warehouse complex and sub-divided into four regions 11, 12, 13 and 14. Around each region is placed an inductive loop 21, 22, 23 and 24 respectively, the four loops together encompassing the entire area 10. Each loop will be located in known manner, being supported by the structure if the region is inside a building, and being buried if the region is an outside space. Each loop is fed by its own amplifier unit 31, 32, 33 and 34, which will be described in more detail later. Each amplifier unit feeds its own loop with a low-frequency carrier signal modulated in some convenient manner, and the four amplifier units are controlled by a common control unit 40.

Each object to be located carries a transponder, shown schematically in Figure 1 at 41. The transponders are responsive to the energy within the inductive loops, and comprise a suitable receiver R, a processor P, and a transmitter T· Each transponder transmitted is operable to radiate an uniquely-modulated radio-frequency carrier signal of different frequency to the low-frequency signal applied to the loop.

The remaining piece of equipment is a receiver, shown at 42, in Figure 1, which is responsive to the signals radiated by all the transponders. The receiver includes means for determining from the nature of the received

signal both the identity of the transponder and also the region in which it is located.

Any suitable modulation method may be used to modulate both the loop carrier and the transponder carrier, varying from simple amplitude modulation to complex frequency or pulse-code modulation techniques. The carrier and modulation frequencies used depend to a large extent upon the application. In the case being considered the main problem is one of power consumption, since it may not be possible to provide anything other than a small battery to power the transponder. Since an inductive loop is used to send signals to the transponder, this necessitates the use of frequencies in the low-frequency range, say of the order of 10—200 KHz. Because of the power consumption problem, however, transmission from the transponder is preferably at VHF or UHF.

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Figure 2 illustrates in block diagram form the amplifier unit 32. Preferably the amplifier unit comprises a carrier frequency generator 51, a modulation frequency generator 52, a modulator 53 and a power amplifier 54 feeding into the inductive loop. Preferably all the loops are fed with the same loop carrier frequency f_L of, say, 150 KHz. In order to distinguish between the loops, the carrier frequency is modulated by an unique loop modulation frequency w_L. For example, the modulation frequency applied to the carrier in loop 21 may be 10 KHz, that in loop 22 may be 10.5 KHz, that in loop 23 may be 11 KHz, and so on. Thus, as shown in Figure 2, the output of the modulator 53 is a 150 KHz carrier modulated at 10.5 KHz. As already stated, the modulation method may employ any of the well-known techniques.

The transponder is shown in block form in Figure 3. This comprises basically a low-frequency receiver, a processor and a VHF transmitter. The receiver R comprises basically an antenna 60, an R.F. amplifier 61 and a demodulator 62. The output of the demodulator is the unique loop modulation frequency w_L of 10.5 KHz.

The processor P of the transponder operates to modify the loop modulation frequency in some manner. As shown, the processor comprises a modulator 64 to which is applied the receiver output and also the output of a sine-wave oscillator 65. The oscillator generates the unique transponder modulation frequency w_T, each transponder having a different frequency, such as 100 KHz, 101 KHz, 102 KHz, and so on. Hence the transponder processor Figure 3 has as its output a 101 KHz signal modulated by the loop modulation signal of 10.5 KHz.

The transmitter T comprises a modulator 66 in which is supplied the common transponder carrier frequency of 100 MHz from oscillator 67. This is modulated by the output of the processor. The output of the modulator 67 is then fed through a power amplifier 68 to the transmitting antenna 69. The transmitted signal thus comprises a transponder carrier frequency f_T of 100 MHz modulated by the unique transponder modulation frequency w_T of 101 KHz which is itself modulated by the unique loop modulation frequency w_L of 10.5 KHz. It is preferable to use a common transponder carrier frequency f_T for all the transponders in the system.

The common VHF receiver 42 (Figure 1) may require multiple antenna to ensure reception of the signals from all the transponders in the area. The recevier signal is demodulated to remove the 100 KHz signal carrier, and the resultant 101 KHz signal identifies the transponder, and hence the object with which it is located. Further demodulation produces the unique 10.5 KHz loop modulation frequency, which identifies the region in which the particular transponder is located.

Movement of the transponder from one region to another will result in a change in the loop modulation frequency w_L, and this will be detected by the receiver 42. Preferably the receiver is connected to some form of display or recording device to indicate the position of each transponder.

With a transponder system it is not necessary to "interrogate" the transponder continuously. In particular, in the application being considered each transponder need be interrogated only, say, once per minute. The control unit 40 will cause each of the amplifiers 31, 32, 33 and 34 to feed signal power into its associated loop only at the appropriate times.

In the system described above it has been assumed that each loop is distinguished by an unique loop modulation frequency w_L, impressed upon the common loop carrier frequency f_L by suitable modulation techniques. An alternative method of distinguishing between the regions is to feed a common identification signal power to only one loop at a time. In this case only the transponder located within the energised loop will radiate to the receiver 42. This may be considered as on-off modulation of the loop carrier frequency, even though the duty ratio will perhaps be very small.

The type of modulation used in the transponder processer and transmitter may vary. One convenient form produces the same effect as frequency-shift keying by producing a frequency shift of the transponder carrier f_T by the transponder modulation frequency w_T at a rate determined by the loop modulation frequency w_L.

One problem which may have to be considered, especially in the case of very valuable cargoes such as bullion, is that assempts may be made to interfere with the system so that

the cargo, and its transponder, may be removed without warning being given. It is a relatively simple matter to ensure that removal of the transponder will give an alarm, say by producing continuous radiation. Equally, if the transponder is damaged or destroyed the failure to respond to interrogation may be made to give an alarm.

A more serious consideration is that of electronic countermeasures, commonly referred to as ECM, which may arise if cargo is sufficiently valuable. Saturation jamming by continuous radiation at either or both of the common carrier frequencies is readily detected, but it might be possible for a would-be jammer to obtain precise information of inindividual frequencies, interrogation timings etc. ECM of this nature may be frustrated by changing loop modulation frequencsies and transponder reply timings at irregular intervals. Such arrangements would probably require the use of a computing device to ensure that the receiver 42 was aware of these changes to detect false signals and other alarm indications. Other, more sophisticated, methods of preventing ECM may be envisaged.

The frequencies referred to in the above example are only typical values, and are in no way limiting. The use of loop modulation frequencies 500 Hz apart allows the provision of 21 unique frequencies between 10 KHz and 20 KHz. Similarly the use of transponder modulation frequencies 1 KHz apart allows for 51 transponder within the range 100 KHz to 150 KHz.

To avoid the directional problem which may arise with the transponder receiving antenna, it is possible to use three or more antennae with separate demodulators, adding the three demodulated outputs.

The oscillators in the amplifiers 31 to 34 and in the transponder need not be sine-wave oscillators.

The processor of the transponder may be arranged to perform timing, time delay or switching functions if required.

WHAT WE CLAIM IS:—

1. Means for automatically determining the position of each one of a number of objects within an area, which includes a number of inductive loops together dividing the area into separate regions, means for applying to each inductive loop a separate modulated low-frequency carrier wave, a transponder located with each object and capable of responding to the radiated energy in each inductive carrier wave, and receiving means responsive to the radio-frequency carrier wave radiated by each transponder to determine the identity of the object and the region within which it is located.

2. Means as claimed in Claim 1 in which each transponder includes a receiver operable to extract the loop modulation frequency from the low-frequency radiated energy within an inductive loop, a processor operable to modify that loop modulation frequency in a manner unique to that transponder, and a transmitter operable to radiate a radio-frequency carrier wave modulated by said uniquely-modified loop modulation frequency.

3. Means as claimed in Claim 2 in which the processor of each transponder modifies the extracted loop modulation frequency by modulating it with an unique transponder modulation frequency.

4. Means as claimed in any one of Claims 1 to 3 in which power is applied to two or more inductive loops simultaneously, the loop modulation frequency of each such loop being different.

5. Means as claimed in any one of Claims 1 to 3 in which power is applied to the inductive loops one at a time.

6. Means as claimed in any one of the preceding claims in which the low-frequency carrier waves applied to the inductive loops are all of the same frequency.

7. Means as claimed in any one of Claims 1 to 6 in which the carrier waves transmitted by the transponders are all of the same frequency.

8. Means for automatically determining the position of each one of a number of objects within an area substantially as herein described with reference to the accompanying drawings.

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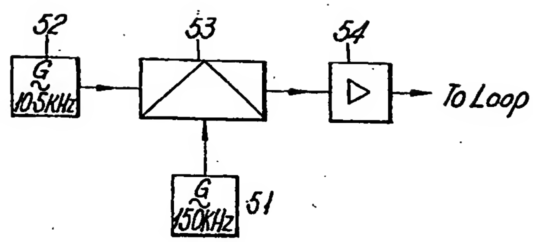
52
53
54
G
105KHz
To Loop
G
150KHz
51

Fig.2

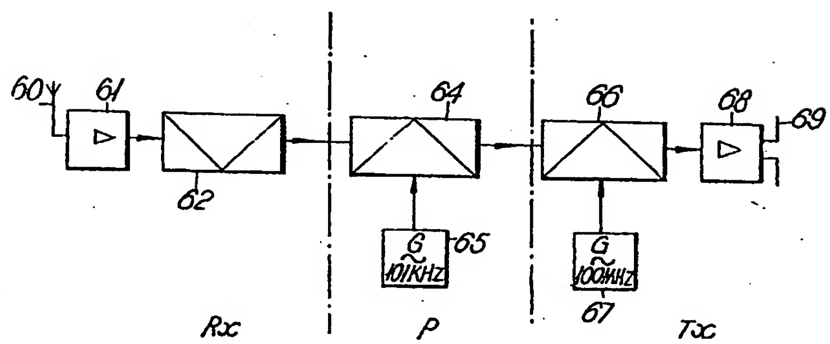
60
61
64
66
68
69
62
G
101KHz
65
G
100KHz
67
Rx
P
Tx

Fig.3